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INTERNATIONAL APPLICATION NO.
PCT/AU00/01002

INTERNATIONAL FILING DATE
August 24, 2000

PRIORITY DATE CLAIMED
September 16, 1999

TITLE OF INVENTION
HOT SPRUE SYSTEM FOR DIECASTING

APPLICANT(S) FOR DO/EO/US
Graham Louis WILSON

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☒ is attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
 - a. ☐ is attached hereto.
 - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: Verified Statement Claiming Small Entity Status - Small Business Concern, Verified Statement Claiming Small Entity Status - Independent Inventor, Form PCT/IPEA/409, Form PCT/IPEA/416, Form PCT/ISA/210, Form PCT/IB/304, Form PCT/IB/308, Form PCT/IB/301, and certified copy of Australian provisional patent application number PQ 2907

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of Graham Louis WILSON	
New U.S. National Stage Patent Application of PCT/AU00/01002	Docket No.: 146381.00003
International Filing Date: August 24, 2000	U.S. National Stage Filing Date: February 25, 2002
For: HOT SPRUE SYSTEM FOR DIECASTING	

PRELIMINARY AMENDMENT

Honorable Commissioner of Patents
and Trademarks
Washington, D.C. 20231

Sir:

Prior to examination of the above-identified application, Applicants respectfully request that the following amendments be entered into the application:

IN THE CLAIMS:

Please replace claims 3-5, 9-12, 15-18 and 20 with the following amended claims:

3. A method according to claim 2 including the step of:

uniformly accelerating the molten diecasting metal as it flows along the melt path, the uniform acceleration of the diecasting metal being enabled by uniformly reducing the cross-sectional area of the channels of the melt path in the direction of flow.

4. A method according to claim 2 including the step of conveying the shot of molten diecasting metal in a smooth curve through an angle of approximately 90^0 while it is within the transition channel.

5. A method according to claim 2 wherein the transition channel is split so that a first part thereof is located by the fixed die and a second part thereof is located by the moving die, the method including the step of:

controlling the temperature of the second part of the transition channel independently of the temperature of the moving die so as to ensure that the freeze-point of the diecasting metal occurs within the transition channel after a shot.

9. A die set according to claim 6 wherein the cross-sectional area of the sprue channel reduces uniformly in the direction of melt flow so that the velocity of the melt increases uniformly within the sprue channel during a shot.

10. A die set according to claim 6 wherein the cross-sectional area of the portion of the melt path which comprises the sprue channel, the transition channel and the runner channel reduces uniformly in the direction of melt flow so that the velocity of the melt increases uniformly within said melt path.

11. A die set according to any claim 6 wherein said angle is substantially 90^0 .

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12. A die set according to claim 6 having an ejector pin slidingly located within one of said dies for movement into the transition channel so as to be adapted to eject diecasting metal that solidifies within the transition channel after a shot and after separation of the movable and fixed dies.

15. A sprue insert-set according to claim 13 wherein said angle is substantially 90° and the first curved groove subtends substantially 90° .

16. A sprue insert-set according to claim 13 wherein the sprue body insert includes temperature sensor means.

17. A sprue insert-set according to claim 13 wherein the sprue body insert includes thermal insulation encompassing the heater means so as to mitigate the loss of heat from the sprue insert to the fixed die when the sprue insert-set is in use.

18. A sprue insert-set according to claim 13 including:
a sprue tip insert adapted for mounting within the moving die, said tip insert having an inner end forming said second curved groove.


20. A sprue insert-set according to claim 18 wherein said tip insert includes temperature sensor means and thermal insulation adapted to mitigate thermal transfer between said second insert and the moving die.

REMARKS

Applicants respectfully request that the foregoing amendments to claims 3-5, 9-12, 15-18 and 20 be entered in order to avoid this application incurring a surcharge for the presence of one or more multiple dependent claims. A marked-up copy of the amended claims is enclosed in Appendix I.

Early examination is respectfully requested.

Respectfully submitted,



David W. Woodward
Registration No. 35,020
Attorney for Applicant

POWELL, GOLDSTEIN, FRAZER & MURPHY, LLP

P.O. Box 97233
Washington, D.C. 20090-7223
202-347-0066

Date: **February 26, 2002**

DWW/yea

APPENDIX

Changes in the Claims:

The following are marked-up versions of the amended claims:

3. A method according to claim ~~1~~^{or} 2 including the step of:

uniformly accelerating the molten diecasting metal as it flows along the melt path, the uniform acceleration of the diecasting metal being enabled by uniformly reducing the cross-sectional area of the channels of the melt path in the direction of flow.

4. A method according to ~~any preceding claim~~ 2 including the step of conveying the shot of molten diecasting metal in a smooth curve through an angle of approximately 90° while it is within the transition channel.

5. A method according to ~~any preceding claim~~ 2 wherein the transition channel is split so that a first part thereof is located by the fixed die and a second part thereof is located by the moving die, the method including the step of:

controlling the temperature of the second part of the transition channel independently of the temperature of the moving die so as to ensure that the freeze-point of the diecasting metal occurs within the transition channel after a shot.

9. A die set according to ~~any one of claims 6 to 8~~ claim 6 wherein the cross-sectional area of the sprue channel reduces uniformly in the direction of melt flow so that the velocity of the melt increases uniformly within the sprue channel during a shot.

10. A die set according to ~~any one of claims 6 to 8~~ claim 6 wherein the cross-sectional area of the portion of the melt path which comprises the sprue channel, the transition channel and the runner channel reduces uniformly in the direction of melt flow so that the velocity of the melt increases uniformly within said melt path.

11. A die set according to ~~any one of claims 6 to 10~~ claim 6 wherein said angle is substantially 90°.

12. A die set according to ~~any one of claims 6 to 11~~ claim 6 having an ejector pin slidably located within one of said dies for movement into the transition channel so as to be adapted to eject diecasting metal that solidifies within the transition channel after a shot and after separation of the movable and fixed dies.

15. A sprue insert-set according to claim 13 ~~or 14~~ wherein said angle is substantially 90° and the first curved groove subtends substantially 90°.

16. A sprue insert-set according to ~~any one of claims 13 to 15~~ claim 13 wherein the sprue body insert includes temperature sensor means.

17. A sprue insert-set according to ~~any one of claims 13 to 16~~ claim 13 wherein the sprue body insert includes thermal insulation encompassing the heater means so as to mitigate the loss of heat from the sprue insert to the fixed die when the sprue insert-set is in use.

18. A sprue insert-set according to ~~any one of claims 13 to 17~~ claim 13 including:
a sprue tip insert adapted for mounting within the moving die, said tip insert having an inner end
forming said second curved groove.

20. A sprue insert-set according to claim 18 ~~or 19~~ wherein said tip insert includes
temperature sensor means and thermal insulation adapted to mitigate thermal transfer between
said second insert and the moving die.

Applicant or Patentee:
Serial or Patent No.:
Filed or Issued:
For:

Atty. Dkt. No.

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) AND 1.27 (c)) - SMALL BUSINESS CONCERN**

I hereby declare that I am an official of the small business concern identified below and that I am empowered to act on behalf of this concern:

NAME OF CONCERN: Hotflo Diecasting Pty Ltd
ADDRESS OF CONCERN: 711 Clayton Road, Clayton South, Victoria 3169, Australia

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18 and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of all its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that all right title and interest have been conveyed under contract or law to and remain with the small business concern identified above with regard to the invention entitled:

HOT SPRUE SYSTEM FOR DIECASTING

By inventor: Graham Louis WILSON, of 14 Glenmer Street, Victoria, 3189, Australia

And as described in the specification of PCT International Application No. PCT/AU98/00475 filed on 18 June 1998 [Not amended under PCT Articles].

I hereby declare that the rights held by the above-identified small business concern are exclusive and that no other person or concern has rights thereto by contract, lien, promise, licence or otherwise.

I hereby acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate: (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such wilful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING: Graham Louis WILSON
TITLE OF PERSON SIGNING: Director
ADDRESS OF PERSON SIGNING: 14 Glenmer Street. Moorabbin, Victoria, 3189, Australia

SIGNATURE:

GRAHAM L. WILSON
[Signature]

DATE: 31 January 2002

Applicant or Patentee:
Serial or Patent No.:
Filed or Issued:
For:

Atty. Dkt. No

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL
ENTITY STATUS
(37 CFR 1.9(f) AND 1.27(c)) -INDEPENDENT INVENTOR**

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled:

HOT SPRUE SYSTEM FOR DIECASTING

described in the specification filed with International Patent Application PCT/AU00/01002 on 24 August 2000 and not amended under PCT Articles.

Except as listed below, I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey, or license any rights in the invention in the United States to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

I hereby declare that I have assigned my entire, right and interest in and to the said invention to the small business concern identified below:

FULL NAME OF SMALL BUSINESS CONCERN:

Hotflo Diecasting Pty Ltd

ADDRESS

711 Clayton Road, Clayton South, Victoria, 3169, Australia

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate: (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such wilful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF INVENTOR:

Graham Louis WILSON

ADDRESS OF INVENTOR:

14 Glenmer Street, Moorabbin, Victoria, 3898, Australia

SIGNATURE OF INVENTOR

GRAHAM L. WILSON



DATE OF SIGNING: 31 January 2002

7/1/02

TITLE: HOT SPRUE SYSTEM FOR DIECASTING

TECHNICAL FIELD

This invention relates to high-pressure diecasting methods and apparatus, and more particularly, to hot sprue systems for use with hot-chamber, high-pressure diecasting.

BACKGROUND TO THE INVENTION

There is a very large installed base of hot-chamber, high-pressure, diecasting machines dedicated to the production of small die-cast products of zinc, lead, tin magnesium, aluminum and their alloys. Figure 1 shows a typical machine 10 of this type. A pool of molten metal 12 is held in a heated pot 14 from which 'shots' of melt are forced, by a plunger 16 working in a submerged cylinder 18, through a gooseneck 20 and an externally flame-heated connecting nozzle 22, into a cavity 24 formed between a fixed die 26 and a moving die 28. Fixed die 26 is mounted on a fixed platen 30 and moving die 28 is mounted on a moving platen 32 that is pressed toward the fixed platen by the piston 34 of a hydraulic or pneumatic ram, the clamping force being taken by tie-rods 36. When dies 26 and 28 are closed, plunger 16 is driven downwards into cylinder 18 by the piston 38 of a pneumatic ram 40 to force a shot of melt into cavity 24 and to hold the pressure until it has frozen. After which, plunger 16 is raised to suck the remaining liquid melt from nozzle 22 and gooseneck 20 back into melt pool 12. To assist the flow-back of melt at the end of a shot, nozzle 22 normally slopes upward to fixed die 26. Indeed, for the same purpose, the whole press portion of the machine (comprising the dies and platens) can be tilted slightly downward towards nozzle 22.

At the commencement of a shot, the melt is conveyed from heated nozzle 22 through a sprue bush 42 fitted in the back of fixed die 26 and through a sprue channel 44, formed in the fixed die 26, to the interface or parting-line 46 of dies 26 and 28. It is then conveyed along the interface 46 by one or more runner channels 48, through a gate orifice 49, into cavity 24. As the injection pressure in such machines is commonly between 10 and 30 mPa, nozzle 22 must be pressed hard against sprue bush 42 and gooseneck 20 to avoid leakage. The use of sprue bush

42 assists in forming the seal at the die end of nozzle 22 and it has the advantage that it can be easily replaced should a freeze-plug form therein after a shot.

Sprue channel 44 is strongly tapered so that it widens toward die interface 46

5 from sprue bush 42 in the direction of melt flow. It is of such a volume that the freeze-point will occur in sprue channel 44 inwards or down-stream of bush 42 at the end of a shot. On the other hand, the runner channel(s) generally narrow(s) in the direction of melt flow (i.e., towards gate 49) so that the melt is accelerated and enters the cavity at high velocity. This common arrangement of sprue and runner
10 channels allows the cast sprue and runner(s) to be easily removed from the dies, together with the attached products, as one piece after the dies have opened. Each runner channel 48 is normally connected to its respective cavity 24 via narrow slot-like gate 49 so as to form a thin and easily broken connection between the product casting and it's attached runner and sprue castings.

15 It will be appreciated from the above that, in this specification, the sprue and runner channels form a melt path within the dies that conveys the melt to the cavity gate(s). The sprue channel conveys the melt from the exterior (normally the back) of the fixed die to the front face – or parting-line – of the fixed-die, while
20 each runner conveys the melt from the sprue channel to the respective cavity gate along the interface between the fixed and moving dies. The sprue and runner castings are the die-cast metal that solidifies in the sprue and runner channels (respectively) at the end of a shot.

25 Though hot-chamber diecasting is very common, relatively trouble-free and can produce high quality product at high production rates, a major disadvantage of the technique is the large amount of metal contained in the sprue and runner castings compared with the metal in the product. After detachment from the products, the sprue and runner castings are generally remelted and reused, but this represents
30 high-energy losses and causes melt contamination. Another significant disadvantage of conventional hot-chamber diecasting is the abrupt discontinuity in both section and direction in the melt path between the wide and widening sprue

channel and the narrow and narrowing runner channel(s); a discontinuity which leads to turbulent and inefficient melt flow.

It will be appreciated that hot-chamber diecasting is a similar process to the injection moulding of plastics materials. While both can pump shots of melt into cavities via sprue and runner systems, losses associated with the sprue and runner castings are much less with injection moulding. In injection moulding, it is common to employ electrically heated sprue-channels (often called 'nozzles' in the injection moulding context), or electrically heated cores (called 'hot-tips') within the sprue-channels, to eliminate the generation of sprues. Indeed, if such a device is used to inject molten plastic directly into a cavity, both runners and sprues can be eliminated. It is even possible to use a mechanical valve in the sprue nozzle or hot-tip to close the channel at the entrance to the cavity so that the molten plastic feed-line can be kept pressurized between shots, allowing very high production rates.

While it has been suggested from time to time (see for example US patents 4,304,544 and 4,795,126 to Crandell) that heated nozzles and hot-tips designed for injection moulding can be used for direct-injection diecasting, this has proved impractical. The much higher melting point, thermal conductivity and electrical conductivity of metals relative to plastics have made direct-injection diecasting problematic.

The most notable attempt at direct-injection in hot-chamber diecasting known to the applicant is that undertaken by the Battelle Columbus Laboratories for the International Lead Zinc Research Organization [ILZRO] during most of the 1980s. A large number of progress reports were prepared and published on this work by ILZRO or Battelle. An early such report was published in a paper (No. G-T83-066) entitled "Heated Manifold, Direct-Injection System for Zinc Diecasting" by Groeneveld and Kaiser of Battelle and Herrschaft of ILZRO at the International Diecasting Congress and Exposition, Minneapolis, October 31 to November 3, 1983. A further progress report, entitled "Commercial Application of the Heated-Manifold Direct-Injection System of Zinc Diecasting" was published in a paper at

the Exposition of June 3-6 1985 in Milwaukee, WI, with Groeneveld of Battelle as primary author. A further progress report (No. 30) on the ILZRO direct-injection project (authored by Groeneveld) was published by in March 1988, noting that "several million castings have been made by direct injection". Production rates and product quality were reported to be at least equal to conventional diecasting using runners and sprues.

Despite the obvious and great benefits offered by direct-injection diecasting, the technique disclosed in the above publications (particularly, the Battelle work) has not been widely applied by the diecasting industry. The principal reason for this appears to be that die and 'nozzle' design methods for direct injection have not been developed to anywhere near the same facility and reliability as die, runner and sprue design techniques for conventional hot-chamber diecasting.

Consequently, a great deal of highly-expert and highly-expensive experimentation must be undertaken before any given product, cavity, die, machine and 'nozzle' combination can be made to work satisfactorily. Furthermore, direct-injection in multi-cavity dies involves major changes to existing diecasting machines with respect to metal flow and control, making machine set-up and tool-changing lengthy processes. In short, implementation of direct-injection diecasting appears to be beyond the technical ability as well as the financial capacity of the great majority of hot-chamber die-casters.

OUTLINE OF INVENTION

The present invention is based upon the realization that a significant part of the benefit offered by direct-injection diecasting can be achieved with very little change to current die design and no change to hot-chamber machine layout, if a heated sprue channel is employed with a substantially conventional runner channel and if a curved transition channel connects the sprue channel to the runner channel. The temperature of the sprue channel can be controlled to ensure that the melt can run back from the sprue channel after each shot, while the temperature of the transition channel can be arranged so that the freeze-point occurs therein. If the die parting-line includes the transition channel, the casting formed therein (integral with the runner casting) can be ejected with the runner

casting in the normal manner. The use of separate mating die inserts to define the transition channel enables the temperature of that channel to be controlled independently of the sprue insert and die temperature. One of the die inserts is preferably a heated sprue body insert in the fixed die, while the other is preferably an opposing, mating and cooled sprue tip insert in the moving die.

Such a 'sprueless' diecasting technique can avoid the production, recovery and remelting of sprues (and so achieve most of the savings of direct-injection) with minimal change to die design, no change to machine layout and without any need for troublesome valved injection nozzles. Furthermore, the use of a hot-sprue die-insert allows the melt flow-path within the die to be optimized for streamlined flow without the need for any abrupt change of section. Indeed, gradual and uniform tapering of the melt path is readily achieved from the sprue inlet to the gate so that the melt is constantly and smoothly accelerated. The need for a reverse taper on the sprue channel to permit withdrawal of a sprue casting is, of course, eliminated.

It will be normal for the sprue channel to extend roughly horizontally in the fixed die so as to be orthogonal to the die parting-line and the back of the fixed die (as is conventional) and for the transition channel to be a smooth curve that subtends an angle of about 90° from the sprue channel to the runner channel. However, the sprue and/or the die parting-line may be oriented so that the angle subtended by the curve of the transition channel is other than 90° , though this will be unusual. As already noted, the transition channel can be made to decrease (taper) in cross-section in a smooth and uniform manner so that the melt is accelerated as it flows around the curve to enter the runner channel.

It is preferable that the insert in the moving die that defines portion of the transition channel has its own cooling means (such as provision for coolant circulation) so that its temperature can be adjusted independently of the rest of the moving die so as to ensure that freeze-off occurs in the transition channel. For this purpose, it is desirable for the insert to include temperature sensor means so that automatic regulation can be effected. Similarly, it is desirable for the sprue-

insert in the fixed die to include temperature sensor means so that it can be kept at a sufficiently high temperature to ensure flow-back of the melt after a shot.

It will be appreciated that mating die inserts like those required to define the transition channel are familiar to average diecasting toolmakers and that the setting of appropriate temperatures for the sprue and transition channels to achieve appropriate flow-back and freeze-off (respectively) are well within the competency of average machine operators. Apart from the need for the die inserts, tool design and machine operation normally will be unaffected by the method of the present invention. Normal cavity inserts and ejection mechanisms can be used. Where there is more than one cavity in a die-set branching or radiating transition channels can be formed in the inserts to connect the sprue channel to the various runner channels.

It will be seen that the present invention relates to diecasting methods, diecasting apparatus and to die-inserts for use in diecasting.

DESCRIPTION OF EXAMPLES

Having portrayed the nature of the present invention, two examples will now be described with reference to the accompanying drawings. However, those skilled in the art will appreciate that many variations and modifications can be made to the chosen examples without departing from the scope of the invention as defined by the following claims.

Brief Description of the Drawings:

Figure 1 is a part-sectional elevation of a typical prior art hot-chamber diecasting machine.

Figure 2 is a diagrammatic sectional elevation of portion showing the die-set of a typical diecasting machine with sprue inserts formed in accordance with the first example of the present invention.

Figure 3 is an enlarged view of portion of Figure 2.

Figure 4. is an enlarged plan view of portion of the die set of Figure 2 taken on section line III-III of Figure 2.

Figure 5 is a perspective view of the sprue-body insert of Figures 2 and 4.

Figure 6 is a perspective view of the sprue-tip insert of Figures 2, 3 and 4.

Figure 7 is a sectional elevation of a die-set having a sprue and a sprue-tip insert formed so as to feed two opposed runner channels.

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Figures 2 - 4 show portion of a conventional diecasting machine 100 in which the die-set 102 is shown closed and mounted between a fixed platen 104 and a moving platen 106. Die-set 102 comprises a fixed backplate 108 secured to fixed platen 104 (with an insulating plate 109 placed there between) and a moving backplate 110 fixed to moving platen 106. A fixed dieblock 112 is secured to fixed backplate 108 and a moving dieblock 114 is secured to moving backplate 110. The interface or parting plane between dieblocks 112 and 114 is shown at 115. A bolster 116 is secured to each side of moving backplate 110 so as to transfer the force of moving platen 106 to moving dieblock 114 around an ejector assembly 118, which comprises a pair of ejector plates 120a and 120b that capture the heads of a set of four product ejector pins 122 and a single runner ejection pin 124.

A mould cavity 126 is formed between the faces of a fixed cavity insert 128 located in fixed dieblock 112 and a moving cavity insert 130 located in moving dieblock 114. Fixed cavity insert 128 has a cooling passage 132 (shown in broken lines) connected to fluid couplings 134 in dieblock 112 and moving cavity insert 130 has a cooling passage 136 (shown in broken lines) connected to fluid couplings 138 in dieblock 114. Runner channels 140a are formed between die inserts 128 and 130 connecting to a runner channel 140b formed between dieblocks 112 and 114, runner channels 140a being connected to cavity 126 by one or more gates 142. With the die set closed (as shown in Figures 2 and 4) a shot of melt is injected along runner channels 140 into mould cavity 126 to form product and runner castings. Moving platen 106, backplate 110, bolsters 116,

dieblock 114 and die insert 130 are then withdrawn from the fixed portion of the die set while ejector assembly 118 is held stationary. Dieblock 114 therefore slides along pins 122 and 124 to effect the ejection of the product and associated runner castings formed in cavity 126 and runner channels 140.

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As so far as described, die set 102 is quite conventional and typical of those widely employed in the hot-chamber diecasting industry.

The hot sprue system of the first example will now be described with particular reference to the enlarged sectional elevation of Figure 3 and the enlarged plan view of Figure 4. It comprises a cylindrical tubular sprue body insert 150 mounted in fixed backplate 108 and dieblock 122 and an opposed mating cylindrical sprue tip insert 152 mounted in moving dieblock 114, the inserts 150 and 152 being coaxial and their common axis 154 being orthogonal to interface 115. Sprue body insert 150 has a central tapering sprue channel 156 that narrows in section from its outer end 156a to its inner end 156b. The inner ends of inserts 150 and 152 mate near parting-line 115 to define a curved transition channel 158 that subtends an angle of 90° and connects sprue channel 156 to runner channels 140, the parting-line of transition channel 158 being indicated at 160. Both the transition channel 158 and runner channels 140 preferably narrow gradually toward gates 142.

Sprue body insert 150 has a cylindrical exterior about which is wound an electrical heating element 162 that can be supplied with electrical power via a lead 164. Body insert 150 has a mushroom-like head 164 that provides an outer recess 166, which forms a socket for the heated nozzle 168 (Figure 2) of diecasting machine 100, and an inner skirt 170 by which insert 150 is located in fixed dieblock 112. A pin 171 which extends radially from skirt 170 and locates in a groove 172 in fixed dieblock 112, and a ring shim 173 which spaces insert from dieblock 112, ensure that the inner end of body insert 150 mates properly with the inner end of tip insert 152 along parting-line 160. A thermocouple temperature sensor 174 is imbedded in body insert 150 and connected via lead 176 to suitable temperature measurement and control equipment (not shown). Heating element lead 164 and

sensor lead 176 pass through a slot 178 formed in skirt 170 (see also Figure 5). Body insert 150 is held in place by a clamping ring 180 that is secured by bolts 182 to fixed backplate 108, the inner end 184 of insert 150 being a snug fit in dieblock 112 so that there is no leakage of melt from transition channel 158 into the space 186 in dieblock 112 that houses sprue insert 150.

With particular reference to Figure 5 (which does not show electrical heating element 162 or leads 164 and 176), the inner end 184 of body insert 150 has a part conical socket 190, in one side of which one half – indicated at 158a – of curved transition channel 158 (Figure 4) is formed. A convex-curved shoulder 192 is formed on each side of half channel 158a between it and the inner wall of socket 184.

With reference to Figures 3, 4 and 6, sprue tip insert 152 has a part conical plug 194 on its inner end that is shaped to fit snugly into socket 192 of body insert 150. One side of plug 194 is cut away to form a pair of concave-curved shoulders 196 on either side of curved groove 158b that forms half of transition channel 158. Shoulders 196 abut with the complementary shoulders 192 on sprue body insert 150. A central baffled cooling passage 198 is formed in insert 152 that connects to cooling fluid passages 200 formed in moving dieblock 114. A temperature sensor 202 is imbedded in insert 152 and its leads 204 are taken through dieblock 114 to a temperature controller (not shown) that regulates the flow of cooling fluid through passages 198 and 202. Finally, sprue tip insert 152 is rotationally located within its socket in dieblock 114 by the use of a key 206 (Figure 4). [The temperature sensor leads and cooling passages are not shown in Figure 6.]

Once sprue inserts 150 and 152 have been fitted into their respective dieblocks, the diecasting machine 100 is used in the conventional manner described above, except that the temperatures of the sprue inserts are adjusted to ensure that, at the end of each shot, (i) the melt in the sprue channel 156 remains sufficiently fluid to quickly drain back into nozzle 168 and (ii) the runner freeze-point occurs in transition channel 158. As the moving components of die set 102 are withdrawn from the fixed components after each shot, the product is ejected from cavity 126

by ejector pins 122 and the runner and transition castings are ejected from the runner and transition channels 140 and 158 with the assistance of ejector pin 124.

The second example of a hot sprue system formed in accordance with the present invention is shown in Figure 7. As in the first example, the die set includes a fixed back plate 108, thermal insulating plate 109, fixed dieblock 112 and moving dieblock 114. In this example, however, two pairs of die inserts 250 and 252 are employed, fed by respective runner channels 254 and 256. The sprue body insert 258 in this example defines a central tapering sprue channel 260, as before. It is formed, located and clamped as in the first example, except that its inner end is bifurcated to form a pair of opposed curved half transition channels 262 and 264 that connect with respective runner channels 254 and 256. Similarly, the inner end of sprue tip insert 266 is bifurcated to form two opposed curved half transition channels 268 and 270 that connect with runners 254 and 256, mating with the corresponding half transition channels 262 and 264 of sprue body insert 258. As before, body insert 258 has a heating element 272 and tip insert 266 has a cooling passage 274. However, in this example, two ejector pins 276 and 278 are used to ensure that the casting formed in each transition channel is positively ejected when the dies part after each shot.

It will be appreciated from the above description that this sprue-less diecasting method can be easily introduced and operated with standard hot-chamber diecasting machines using only the normal skills of a tool-maker or machine-setter/operator. Only the simplest of adjustment and set-up procedures are required from a machine-setter. Yet, the economies and benefits of sprue-less diecasting are substantial.

However, as previously indicated, many variations and changes can be effected without departing from the scope of the present invention. Though considered advantageous, it is not essential to taper the sprue and transition channels as described in these examples. Satisfactory results can be obtained using non-tapering channels. It will also be appreciated that there are many ways known in the art whereby the sprue inserts can be correctly mounted and positioned in their

respective dieblocks. The methods disclosed in the examples may not suit all die sets or toolmaking techniques and can be readily varied. For example, shims may be used with the sprue tip insert rather than – or in addition to – the sprue body insert in order to effect adjustment. Or, given appropriate machining in the first place, no shimming may be needed. Similarly, the method chosen to fit and clamp the sprue body in place may also be varied as convenient. It is envisaged that thermal insulating material can be formed around the heating element of the sprue body to minimize heat loss to the fixed dieblock. Indeed, the sprue tip insert may also be insulated to minimize heat gain from the moving dieblock. Alternatively, the sprue tip insert need not be insulated or temperature controlled as the temperature the moving dieblock can be such as to hold the tip insert at a temperature which ensures freeze-off in the transition channel.

CLAIMS

- 1 A hot-chamber high-pressure diecasting method employing a fixed die, a
movable die, a mould cavity formed between the fixed and movable dies, and a
5 melt path comprising (i) a sprue channel formed in the fixed die for conveying
molten diecasting metal from the hot chamber into the die, (ii) a runner channel
formed between the fixed and moving dies at an angle to the sprue channel for
conveying molten metal from the sprue channel into the mould cavity via a gate
that is also formed between the fixed and movable dies, and (iii) a curved
10 transition channel for conveying molten metal from the sprue channel to the
runner channel through said angle; the method comprising the steps of:
- heating the sprue channel to a temperature that is higher than that of the
dies and approximating the melting point of the diecasting metal,
- controlling the temperature of the dies so that they are below the melting
15 point of the diecasting metal,
- injecting a shot of molten metal into the sprue channel, transition channel,
runner channel and mould cavity,
- allowing molten diecasting metal remaining in the sprue channel to empty
therefrom while allowing diecasting metal in the runner channel and in portion of
20 the transition channel to solidify to form a runner and while allowing diecasting
metal in the mould cavity to solidify to form a product,
- separating the movable die from the fixed die, and
- ejecting the product from the mould cavity together with the runner from the
runner channel and portion of the transition channel.
- 25
- 2 A hot-chamber, high-pressure diecasting method comprising the steps of:
- injecting a shot of molten diecasting metal through a gate into a mould
cavity via a melt path comprising (i) a sprue channel formed in a fixed die and
having an inlet opening in an exterior surface of said fixed die, (ii) a smoothly
30 curved transition channel formed at least in part between said fixed die and a
movable die that cooperates with the fixed die to form said cavity and said gate,
and (iii) a runner channel formed between the fixed and movable dies, said runner
channel extending between said transition channel and said gate,

heating said sprue channel above the melting point of the diecasting metal while maintaining the temperature of the dies below said melting point,

allowing molten diecasting metal remaining in the sprue channel and in portion of the transition channel after the shot to flow back out of the inlet of the sprue channel,

allowing diecasting metal in the runner channel, portion of the transition channel, and in the gate and the mould cavity to solidify,

separating the movable die from the fixed die, and

ejecting the solidified metal from at least one of the dies.

10

3 A method according to claim 1 or 2 including the step of:

uniformly accelerating the molten diecasting metal as it flows along the melt path, the uniform acceleration of the diecasting metal being enabled by uniformly reducing the cross-sectional area of the channels of the melt path in the direction of flow.

15

4 A method according to any preceding claim including the step of conveying the shot of molten diecasting metal in a smooth curve through an angle of approximately 90° while it is within the transition channel.

20

5 A method according to any preceding claim wherein the transition channel is split so that a first part thereof is located by the fixed die and a second part thereof is located by the moving die, the method including the step of:

controlling the temperature of the second part of the transition channel independently of the temperature of the moving die so as to ensure that the freeze-point of the diecasting metal occurs within the transition channel after a shot.

25

6 A die-set for use in a hot-chamber, high-pressure diecasting process, comprising:

30

- a fixed die forming part of a mould cavity, part of a gate for admitting melt into the cavity and a runner channel for conveying melt to the gate, said fixed die having an exterior face,

- a movable die also forming part of said mould cavity, part of said gate and said runner channel,
- a sprue channel formed in the fixed die for conveying melt from the exterior face of the fixed die, the sprue channel being disposed at an angle to the runner channel,
- a curved transition channel formed between the fixed and the moving dies for conveying melt from the sprue channel through said angle to the runner channel when the dies are closed, and
- heater means associated with said sprue channel adapted to maintain the sprue channel near the melting point of the diecasting metal during operation of the die set.

7 A die set according to claim 6 wherein:

the sprue channel is formed by a first die insert that is fitted within the fixed die, said first insert having an outer end forming an inlet of the sprue channel on the exterior of the fixed die and said first insert having an inner end that forms a first part of the transition channel when the dies are closed, and

a second die insert is fitted in the moving die opposite the first insert, said second insert having an inner end which forms a second part of the of the transition channel when the dies are closed.

8 A die set according to claim 7 wherein:

said heater means comprises an electrical heating element formed around said first insert, and

cooling means are associated with the second insert adapted to cool said second part of the transition channel independently of said first die insert so that, in operation, the freeze-point of the diecasting metal can be made to occur within the transition channel.

9 A die set according to any one of claims 6 to 8 wherein the cross-sectional area of the sprue channel reduces uniformly in the direction of melt flow so that the velocity of the melt increases uniformly within the sprue channel during a shot.

10 A die set according to any one of claims 6 to 8 wherein the cross-sectional area of the portion of the melt path which comprises the sprue channel, the transition channel and the runner channel reduces uniformly in the direction of melt flow so that the velocity of the melt increases uniformly within said melt path.

5

11 A die set according to any one of claims 6 to 10 wherein said angle is substantially 90°.

12 A die set according to any one of claims 6 to 11 having an ejector pin
10 slidably located within one of said dies for movement into the transition channel so as to be adapted to eject diecasting metal that solidifies within the transition channel after a shot and after separation of the movable and fixed dies.

13 A sprue insert-set for use in a high-pressure, hot-chamber diecasting
15 apparatus having a fixed die and a moving die having respective parting faces that cooperate to define a runner channel, a gate and a cavity, the sprue insert-set comprising:

a tubular sprue body insert forming a sprue channel and adapted for mounting within the fixed die at an angle to the parting face of the fixed die, said
20 body insert having an outer end defining an inlet to the sprue channel adapted for location at an external surface of the fixed die, and said sprue insert having an inner end defining an outlet adapted for location in the vicinity of the parting face of the fixed die when the sprue insert is mounted within the fixed die,

heating means associated with the body insert for heating the said insert,
25 a first curved groove formed in the inner end of said body insert adapted to cooperate with a second curved groove associated with the moving die such that, when the body insert is mounted within the fixed die, said first and second grooves cooperate to form a curved transition channel connecting the outlet of the sprue channel to the runner channel when the dies are closed.

30

14 A sprue insert-set according to claim 13 wherein:

the sprue channel and the first curved groove are tapered uniformly in the direction of melt flow so that the velocity of the melt will increase uniformly as it travels from the outlet of the sprue channel to the runner channel when the insert-set is in use and the dies are closed.

5

15 A sprue insert-set according to claim 13 or 14 wherein said angle is substantially 90° and the first curved groove subtends substantially 90°.

10

16 A sprue insert-set according to any one of claims 13 to 15 wherein the sprue body insert includes temperature sensor means.

15

17 A sprue insert-set according to any one of claims 13 to 16 wherein the sprue body insert includes thermal insulation encompassing the heater means so as to mitigate the loss of heat from the sprue insert to the fixed die when the sprue insert-set is in use.

20

18 A sprue insert-set according to any one of claims 13 to 17 including: a sprue tip insert adapted for mounting within the moving die, said tip insert having an inner end forming said second curved groove.

25

19 A sprue insert-set according to claim 18 wherein said tip insert includes cooling means associated with the tip insert whereby the tip insert may be held at a temperature below that of the sprue body insert when the insert-set is in use.

20 A sprue insert-set according to claim 18 or 19 wherein said tip insert includes temperature sensor means and thermal insulation adapted to mitigate thermal transfer between said second insert and the moving die.

30

ABSTRACT

Die inserts and methods for use in high-pressure hot-chamber diecasting are disclosed which substantially eliminate sprue castings and greatly improve melt flow. The die inserts comprise (i) a heated sprue body insert (130, 258) adapted for location in the fixed dieblock (112) of a die set and having a sprue channel (136, 260) and (ii) a cooled sprue tip insert (132, 266) adapted mounting in the moving dieblock (114) of the die set. The sprue body and tip inserts are mounted coaxially so that their inner ends mate with one another in the region of the die parting-line (155) to conjointly form at least one curved transition channel (138, 262, 264) that connects the sprue channel (136, 260) with at least one runner channel (140, 254, 256) formed along the parting-line. The temperatures of the sprue body insert and the sprue tip insert are controlled so that the freeze-point occurs in the transition channel and the melt in the sprue channel is able to run back into the machine nozzle at the end each shot, there by eliminating sprue castings.

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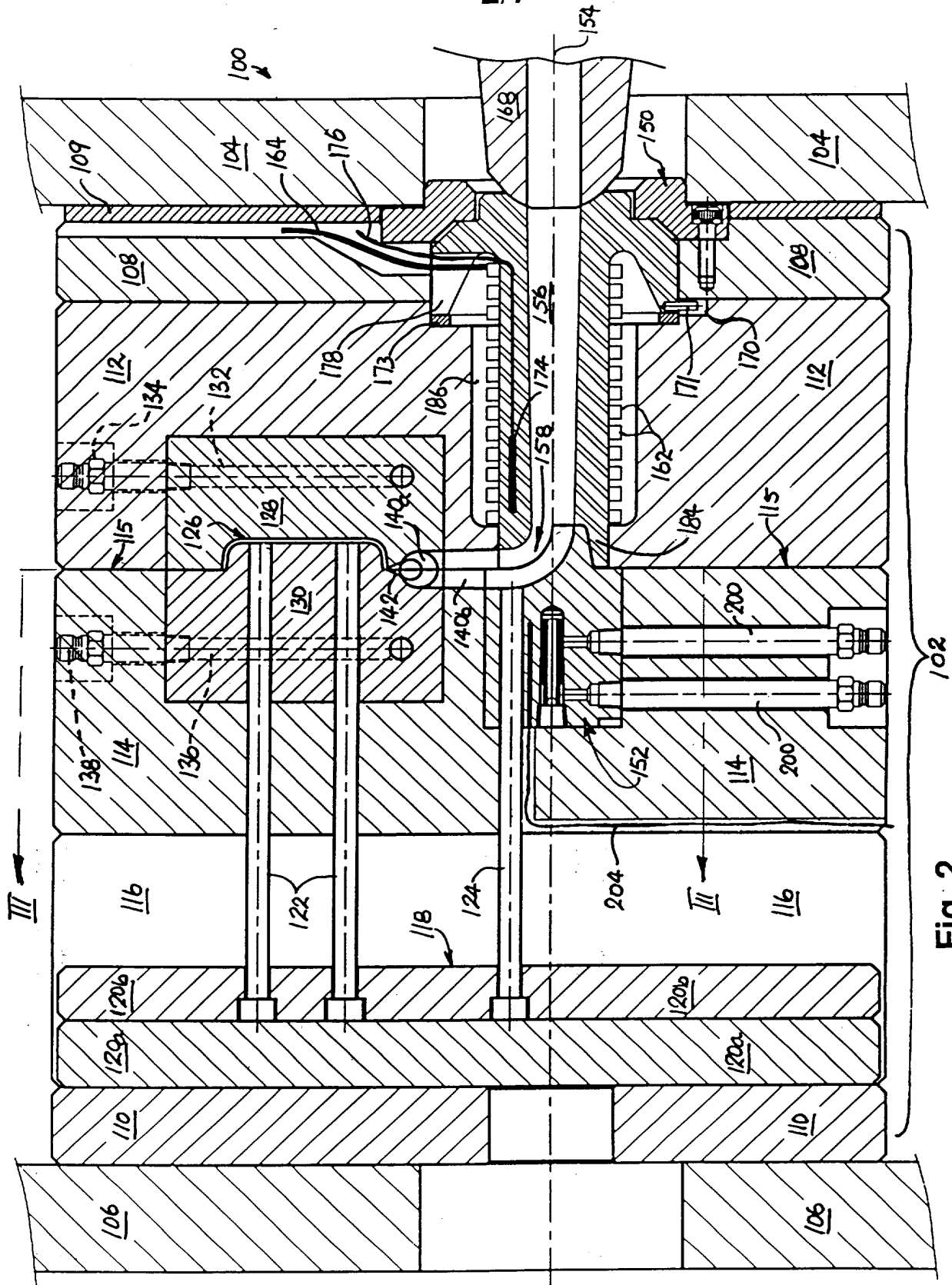


Fig. 2

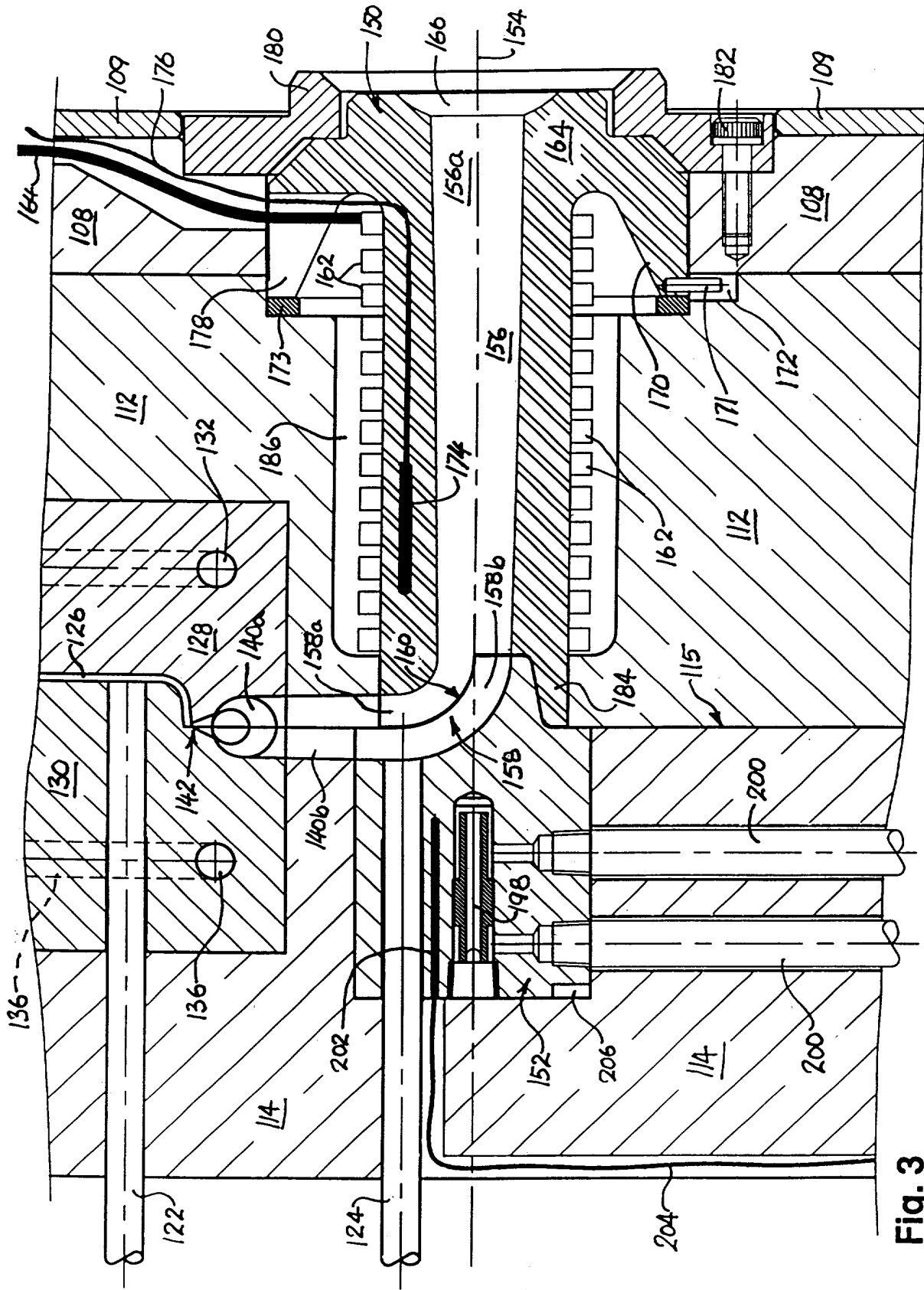
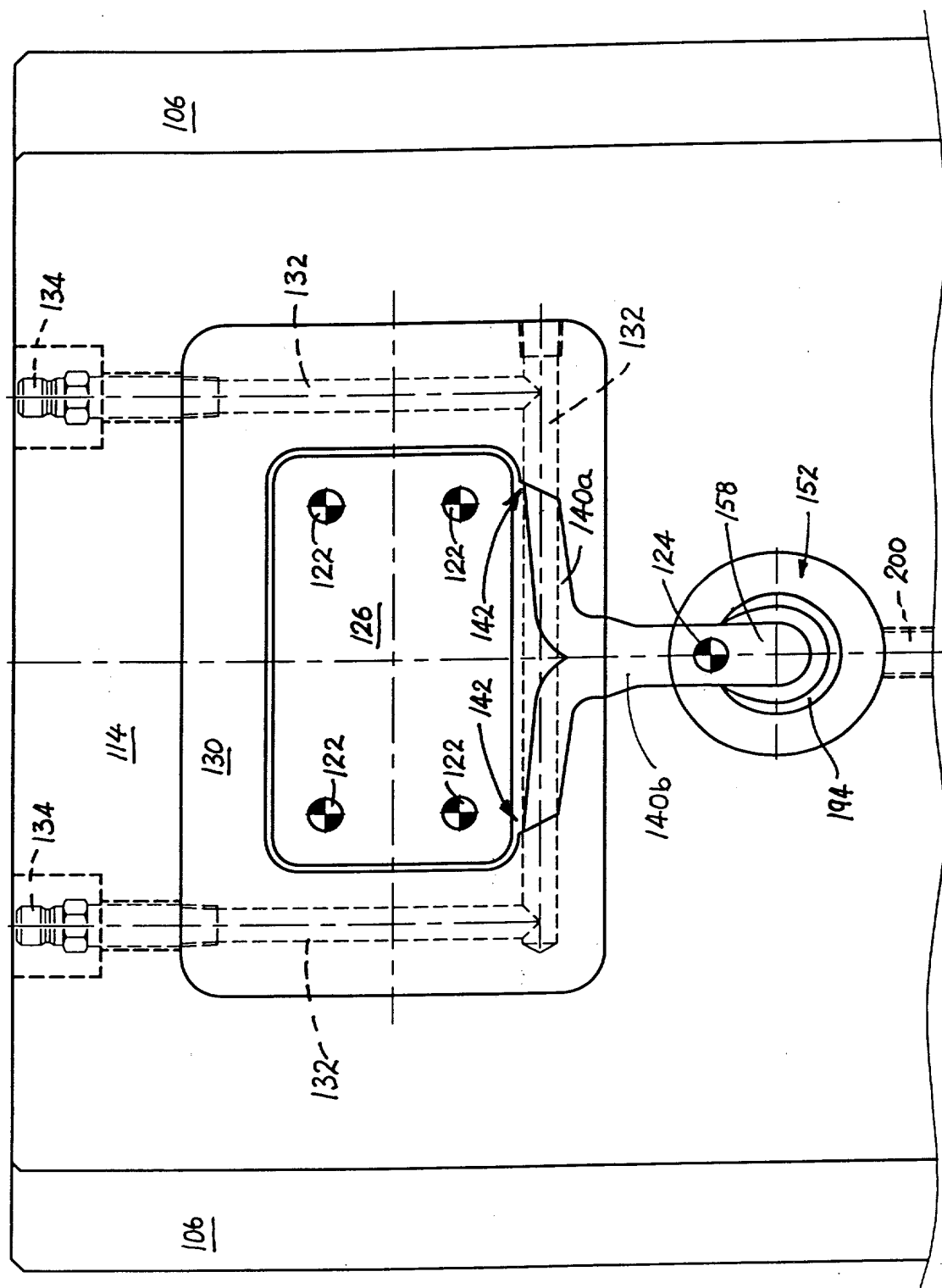


Fig. 3

Fig. 4



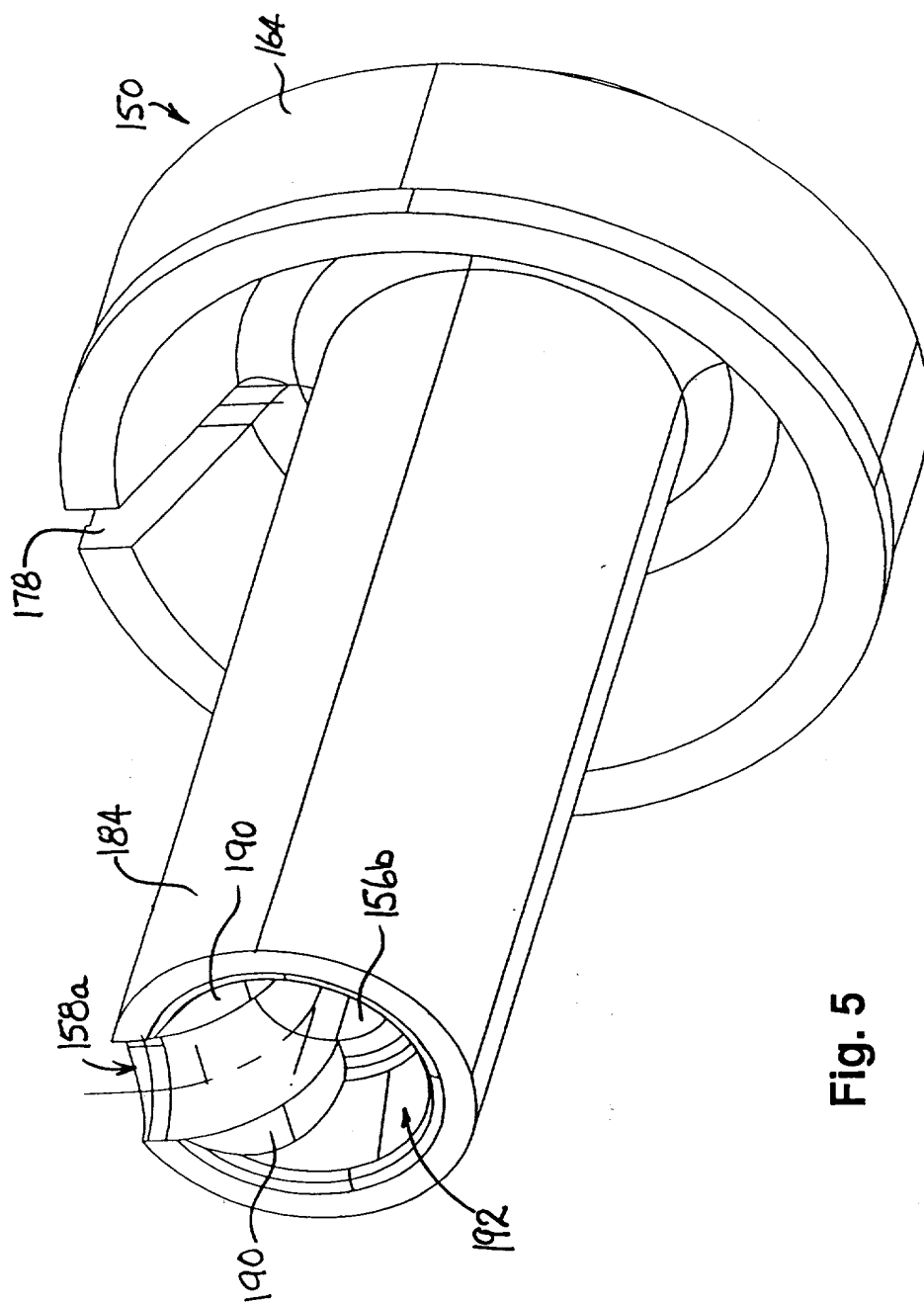


Fig. 5

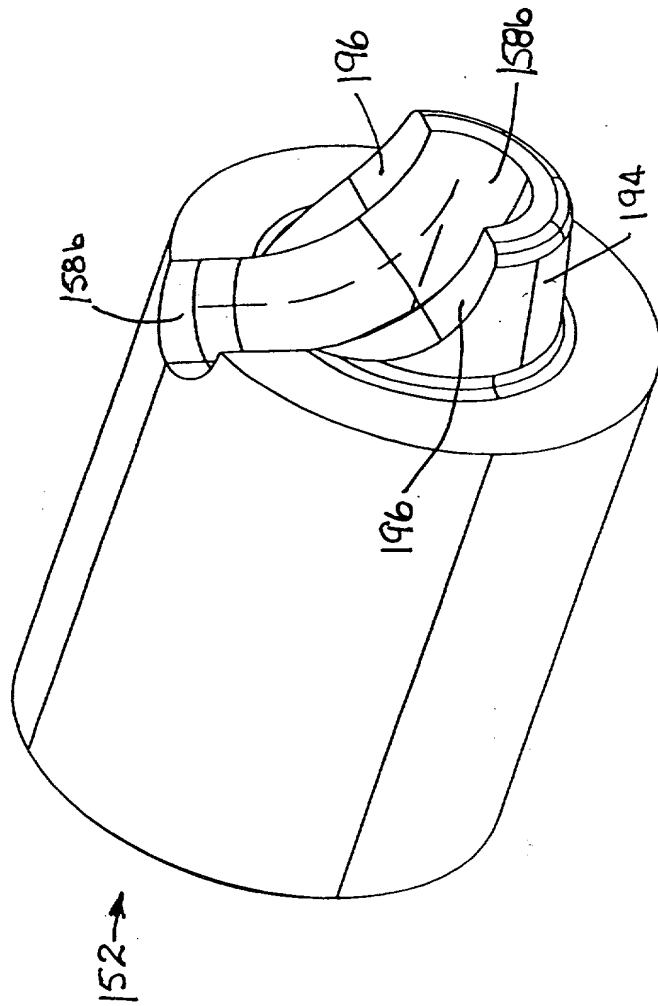


Fig. 6

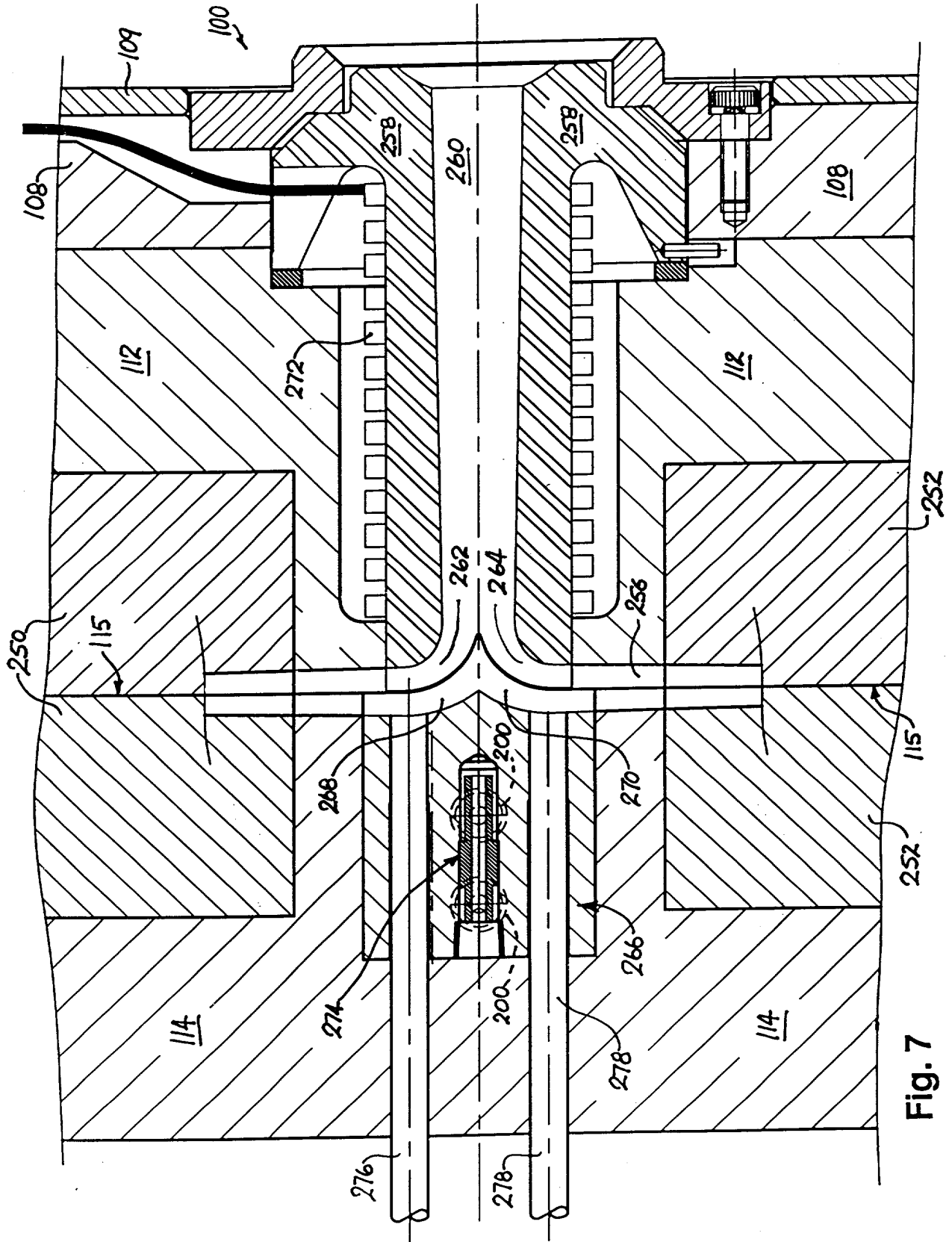


Fig. 7

DECLARATION AND POWER OF ATTORNEY

As the below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

HOT SPRUE SYSTEM FOR DIECASTING

The specification of which

- ☐ is attached hereto.
☐ Was filed on _____ as Application Serial No. _____ and
was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of the above identified application in accordance with Title 37, Code of Federal Regulations, section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, section 119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

PQ2907	AUSTRALIA	16/09/99	Priority Claim
Number)	(Country)	(Day/Month/year filed)	Yes

I hereby claim the benefit under Title 35, United States Code, section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, section 112. I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status
		(Patented, Pending, Abandoned)

DECLARATION AND POWER OF ATTORNEY

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint David W. Woodward, Reg. No.35,020, Jeffrey Kushan, Reg. No.43,401, Thomas T. Moga, Reg. No.34,881, Richard Wilder, Reg. No.31,202, David Fitzgerald, Reg. No.47,347 and Dennis Cawley, Reg. No.44,598, and each principal, attorney of counsel, associate and employee of Powell, Goldstein, Frazer & Murphy, LLP, who is a registered Patent Attorney, my attorney with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith I request the Patent and Trademark Office to direct all correspondence and telephone calls relative to this application to Powell, Goldstein, Frazer & Murphy, LLP, P.O. Box 97233, Washington, D.C. 20090-7223, (202) 347-0066.

Full name of sole inventor: Graham Louis WILSON

Inventor's signature:

GRAHAM L. WILSON

Date:

31 January 2002

Residence & Post Office Address: 14 Glenmer Street, Moorabbin, Victoria, 3189, Australia

Citizenship:

Australian